

# Flash-ADCs at the Karlsruhe van de Graaff

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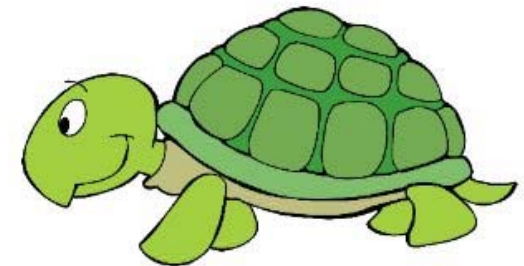
**Workshop on modern methods using fast neutrons for  
research related to the transmutation of nuclear waste**

Dresden, February 13<sup>th</sup> – 15<sup>th</sup>, 2008

# Outline

## How to best use fast digitizers at facilities with high repetition rates?

- A) What's the problem?
- B) How can we use existing digitizers (the n\_TOF DAQ) at the Van de Graaff?  
Three steps towards a DAQ for the Karlsruhe BaF2 detector (40+ channels).
- C) Benefit from new digitizers



# The n\_TOF DAQ

## The n\_TOF DAQ consists of

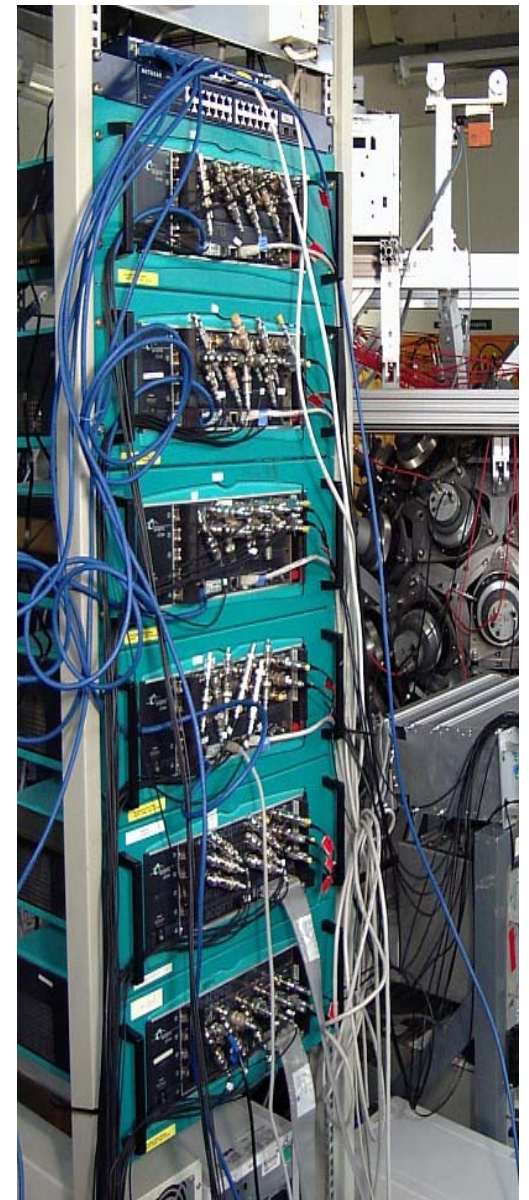
- 50 channels in 6 crates
- A cluster of 8 PCs for readout & processing
- Several TB of disk space between DAQ and tape

## Digitizers: Acqiris DC270 / DC240

Resolution: 8 bit  
Sampling rate: 1 / 2 GHz  
Signal input: 50 mV to 5 V, variable offset

## Configuration most often used @ n\_TOF:

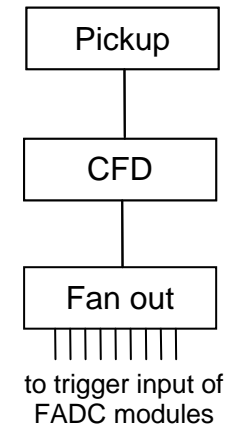
8 MPoints / 500 MHz = 16 ms continuous sampling  
Raw Data: 25 GB/s peak, max 250 MB/s over a few seconds.



# The problem: Data transfer

Interface: PCI-Bus, max. 100 MB/s  
(without overhead)

Repetition rate: 125 - 250 kHz  
4 – 8  $\mu$ s between pulses

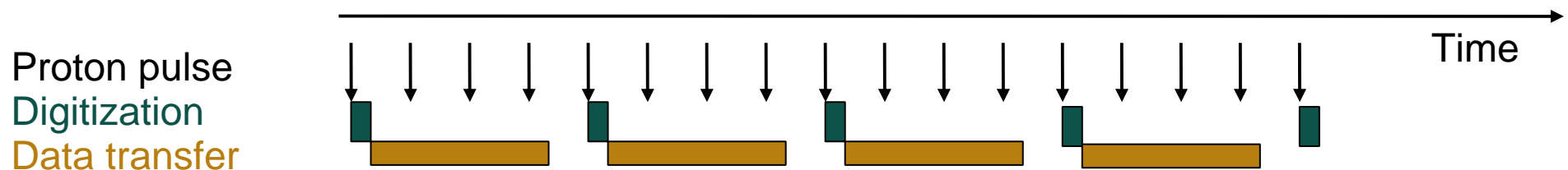


**It is not possible to transfer the acquired data into the PC's memory until the next proton pulse arrives!**

## Example:

Acquired data per event and channel: 1 kB

Transfer time (due to overhead): 30  $\mu$ s



# II. Gating + Calibration needed

- Trigger on detector, segmented mode
- Inhibit trigger during rearming process
- Adjust timing via programmable delays (or cables)
- Adjust pulse-height via (programmable) attenuators (or high-voltage).

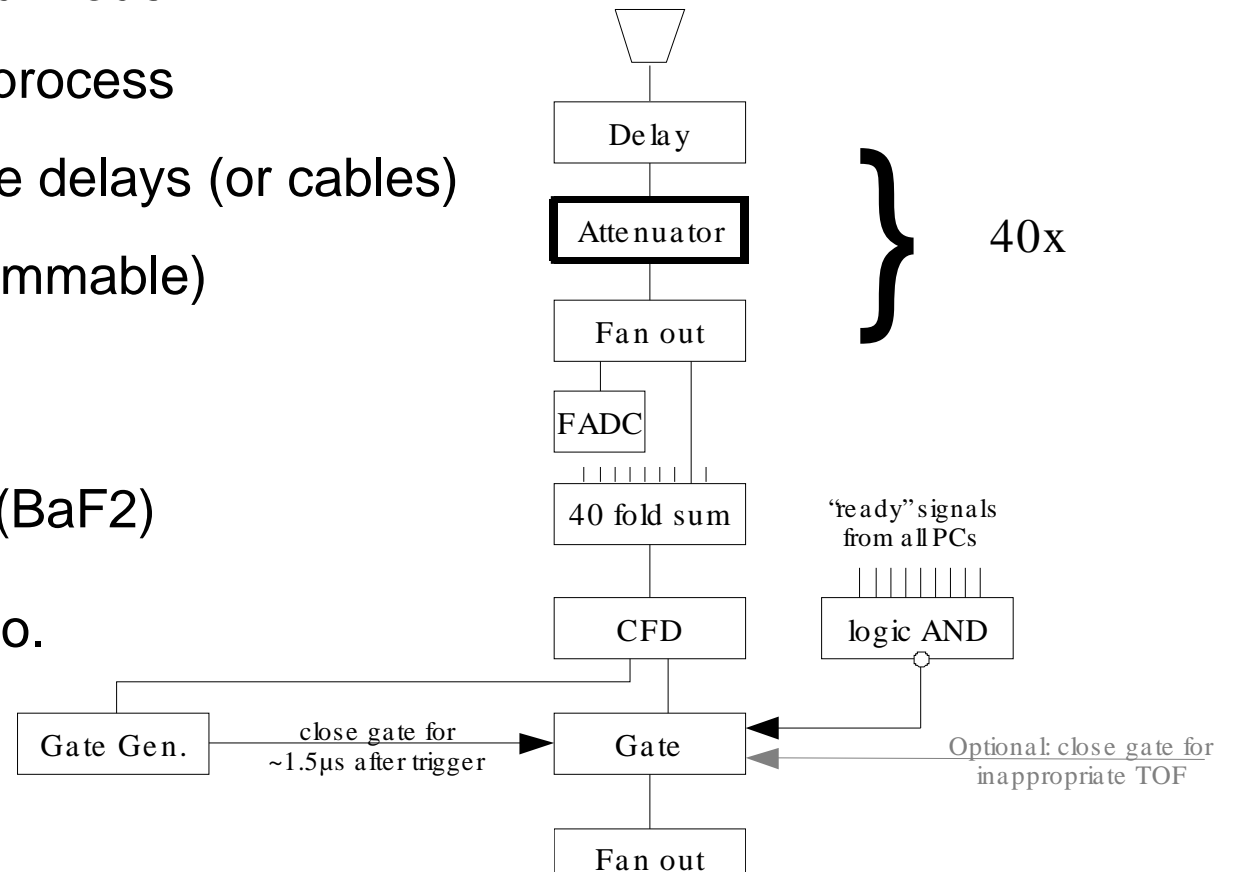
## Example:

Digitize detector signals for 1  $\mu$ s (BaF2)

Digitize pick-up for 1  $\mu$ s (TOF)

Transfer 8000 events/ch in one go.

Transfer-time: 75 ms



Event-rate	Dead-time	
	1 CH	4 CH /PC
1 kHz	0.9 %	3.7%
10 kHz	8.7 %	28%
100 kHz	49 %	79%

# III. Processing and storage of data

- Data (still) needs to be reduced before a one-week-experiment can be stored on disk (16 TB raw data/day for 41 channels at 10 kHz event rate).
- Intense gamma-flash might lead to pile-up between flash and 'good' events. Separation of flash-only events (trash) and pile-ups (good) needs to be done online.
- A simple zero suppression is efficient and fast. CPU power is not a problem anymore (reduction to 800 GB/day).
- More background can be discarded if time-of-flight (or even multiplicity) is available to the readout PCs.
- Lossless compression codes (e.g. huffman) are able to reduce the **remaining** data by more than a factor of 2.



# New hardware, new options...

**Meanwhile, better suited digitizers are on the market:**

- Acqiris DC282:  
10-bits, 4-times faster transfer, SMAR-mode
- Acqiris AP235 with SSR firmware:  
Dead-time free streaming at event rates up to 100 kHz  
(8-bits only)
- “Analyzers”:  
Digitizers with FPGAs can pre-process  
the data before it is transferred to the  
PC.

**There are also other brands on the market!**



# Summary

- Older digitizers can be used although dead-time rises considerably for event rates above 10 kHz.
- New digitizers relax these limits enormously.
- A sophisticated trigger circuit is mandatory in both cases.
- The acquired data is still too large to be stored “as is”.
- Several methods for a online reduction of data have been developed.